ILC Test Accelerator at Fermilab in the NML lab

Introduction

Fermilab is currently building an ILC test accelerator, called NML. The facility will be capable of testing superconducting accelerating modules with an ILC-like beam. Although the ILC program will be the first "user" of this facility, it is anticipated, as the need for ILC-related tests diminishes, that the facility will start providing beam to support Advanced Accelerator R&D projects and experiments.

Facility description & anticipated beam parameters

An overview of the ILC test accelerator is shown in Figure 1. The accelerator complex incorporates an L-band radiofrequency (rf) gun operating at 1.3 Ghz. The bunches are emitted from a CsTe photocathode with a nominal charge of 3.2 nC. The photocathode drive-laser enables the generation of a series of bunches repeated at 3 MHz within a macropulse of nominal duration of 1 ms (see Fig. 2). The beam energy upon exit from the rf-gun is about 4 MeV. The energy is then boosted to 40-50 MeV by two TESLA-type cavities located downstream of the rf-gun. Eventually a 3rd harmonic cavity will be installed, its main purpose being the linearization of the longitudinal phase. The nominal beam parameters out of the injector are shown in Table 1.

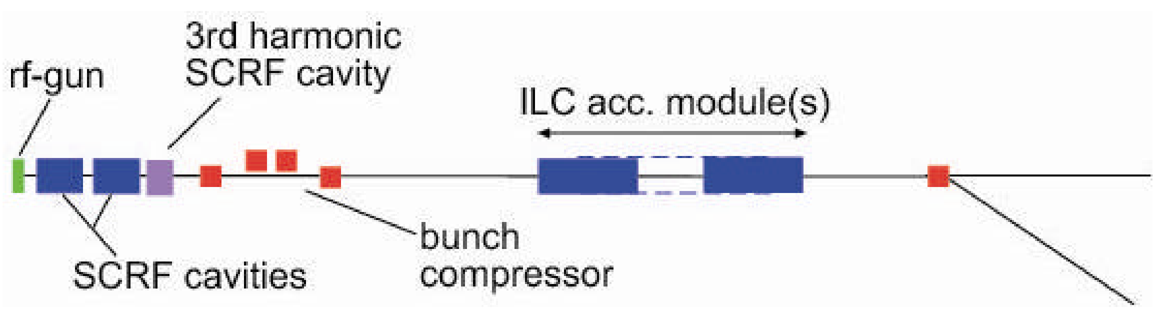

Figure 1: overview of the ILC test accelerator. Green: rf gun, blue: superconducting radiofrequency (SCRF) accelerating cavities, red: dipoles, purple: 3.9 GHz accelerating cavity.

Table 1: Specified nominal beam parameters out of the photoinjector and anticipated range.

Parameter	Symbol	Nominal	Expected Range	Units
charge per bunch	Q	3.2	0.1 – 10	nC
number of bunch/macropulse	N_b	2850	1 – 3000	-
Bunch repetition rate	f_b	3	1-3	MHz
macropulse repetition rate	f_{mac}	5	1-5	Hz
beam total energy	E	40-50	40-50	MeV
rms transverse normalized emittance	e_x, e_y	4-5 (3.2 nC)		μm

The beam then propagates in a 14 meter long transport line before entering the main linac. The transport line incorporates standard elements such as quadrupoles and dipoles, and a magnetic chicane-based bunch compressor. The beamline also includes a round-to-flat-beam transformer capable of manipulating the beam such to generate a high transverse emittances ratio.

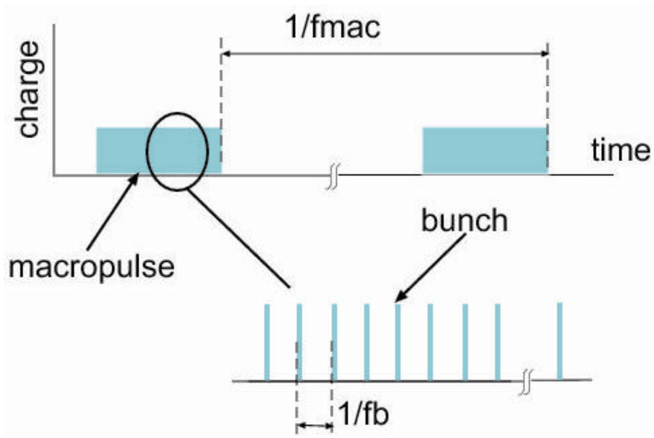

Figure 2: Nominal beam format: the beam consists of a macropulses repeated at frequency f_{mac}. Each macropulse contains about 3000 electron bunches with a repetition frequency f_b.

The main linac will initially (phase 1, Autumn 2007) consist of a single ILC-type accelerating module (that is 8 superconducting cavities with an average accelerating gradient of 25 MV/m). A second accelerating module will be installed in Autumn 2008 (phase 2). Eventually (phase 3 during FY 2009) a third accelerating module will be installed. The anticipate beam parameters are shown in Table 2 for the nominal charge of 3.2 nC. These parameters assume the beam is focused at an interaction point downstream of the accelerating module(s). Tracking simulations including second order effects were performed for the "Autumn 08" scenario and the beam parameters at other energies are obtained from scaling. The flat beam parameters are inferred based on experimental measurement carried at Fermilab A0 photoinjector.

Table 2: Anticipated beam parameters at the interaction point for 3.2 nC

Parameter	Autumn 07	Autumn 08	FY 09	Units
maximum total energy	280	520	760	MeV
Beta functions at IP	0.1	0.1	0.1	m
rms transverse normalized emittance (round)	4-5	4-5	4-5	µm
Beam sizes at IP (round)	30	22	18	µm
rms transverse normalized emittance (flat) e_x, e_y	~0.5,50	~0.5,50	~0.5,50	µm
Beam sizes at IP (flat) s_x, s_y	~10,95	~7,70	~6,58	µm
Peak current	~2.5	~2.5	~2.5	kA